Space Weather Technical Forecast

Issued on Saturday, 22 July 2023 at 13:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of R1/R2 throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate, with an M3.1 flare observed from AR3372, a moderately sized but relatively simple bipolar region on the on the northwest disc. There are currently six sunspot regions visible, and no notable development has been observed. AR3373 is the largest, also located in the northwest, but has remained relatively inactive. AR3379 in the northeast and AR3377 in the southeast are also moderately sized but relatively simple regions that have remained relatively inactive.

The M3.1 flare appears to have produced a CME off the west disc. This remains under analysis, however this is most likely to be missing, or perhaps glancing later towards the end of the forecast period. No other Earth-directed CMEs were observed.

Solar Wind / Geomagnetic Activity: A glancing CME arrival occurred at 21/1927 UTC, with the initially background speeds of around 380km/s being observed by DSCOVR at L1 jumping to just over 400km/s. Speed then erratically varied between 390-450km/s, but with a rising trend by the end of the period due to the onset of the fast wind from CH26/-. Density rose to be above average, peaking at 16ppcc 21/2153 UTC. Interplanetary magnetic field (IMF), Bt, rose from weak at 5nT to be moderate 8-15nT between 21/1927-22/0140 UTC, then became weak again at 6-9 nT thereafter. The north-south component, Bz, was generally variable between +/-7nT but briefly peaked +9nT at 21/2020 UTC before rotating to -15nT at 21/2223 UTC, before easing back by 21/2330 UTC. The phi angle was predominantly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3), with an Active (Kp 4) interval between 21/2100-2400 UTC.

Energetic Particles / Solar Radiation: GOES-16 high energy (greater than 2MeV) electron flux was Background to Moderate, peaking 361pfu at 21/1510UTC. The 24-hour integrated fluence was well below the Active (1e8 integrated pfu) threshold. A fluence of 6.62e6 pfu was recorded at 22/0000UTC. GOES-16 high energy (greater than 10MeV) proton flux continued to ease to background recent enhancements, and remained below 1pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Low with a chance of an isolated M-class flare.

Solar Wind / Geomagnetic Activity: CME from the M3 flare early 22 Jul is still under analysis, however this is likely to either miss or give just glancing impacts later in the period. Otherwise current fast winds are expected to only gradually ease day 2 (23 Jul) before a further enhancement from CH27/- HSS later day 2 or more likely day 3 (23-24Jul). Mainly Quiet to Unsettled geomagnetic activity expected throughout, with a slight chance of Active intervals day 1 (22 Jul) and rising to Active with a slight chance of isolated G1 Minor Storms with any CIR ahead of the CH27/- HSS, most likely on day 3 (24 Jul).

Energetic Particles / Solar Radiation: The high energy electron flux (greater than 2MeV) is expected to vary between background and moderate levels, with a chance of rising to High at diurnal peak. This most likely by day 4 (25 Jul). The associated 24 hour fluence is expected to

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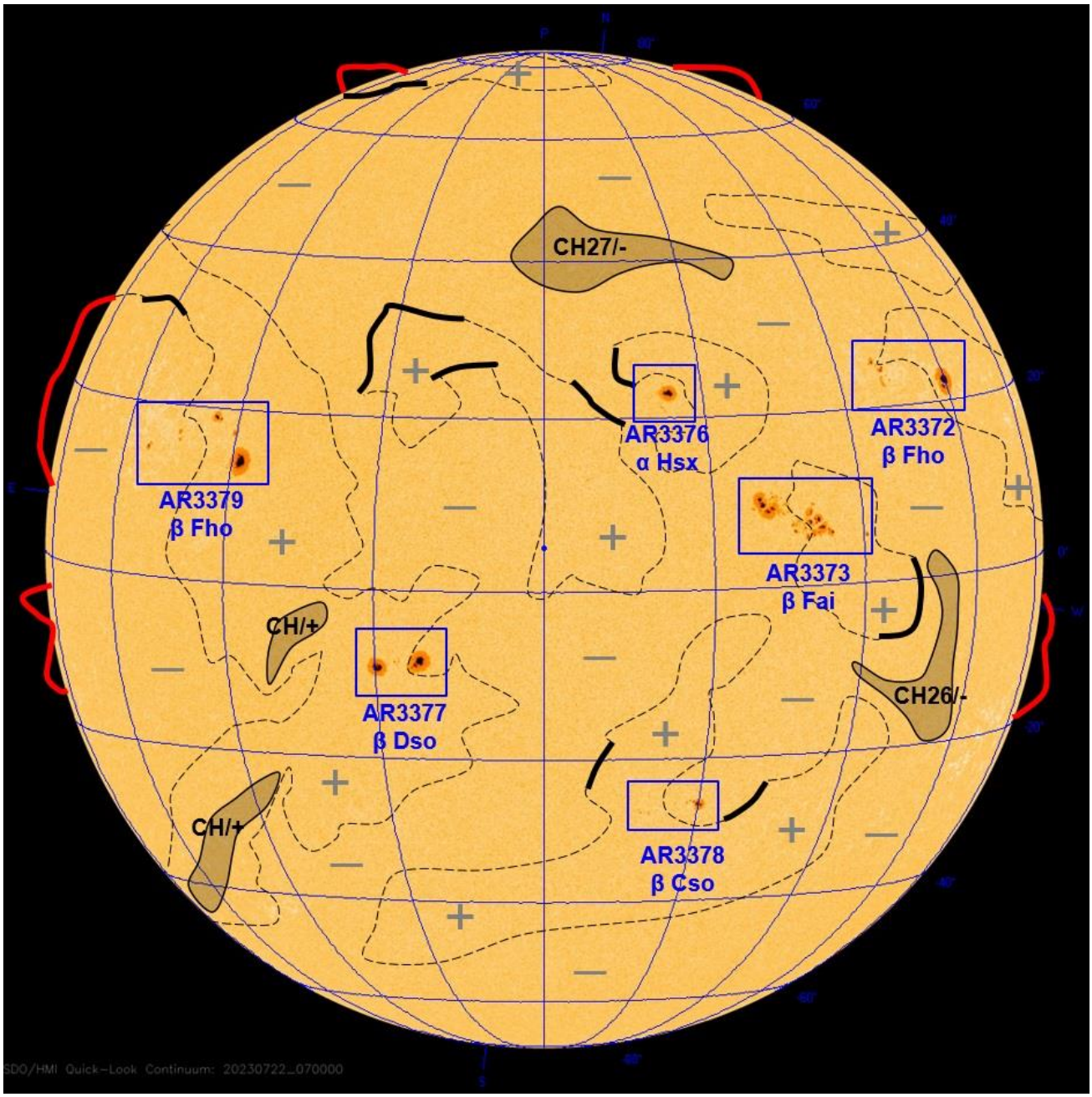
remain below the active (1e8 total pfu) threshold, but likely rising by the end of the period. The high energy (greater than 10MeV) proton flux is now expected to persist at background levels, with only a slight chance of rising again given any large flares from any of the sunspot regions, primarily on the western disc.

Figure 1. Solar Analysis Valid 22/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

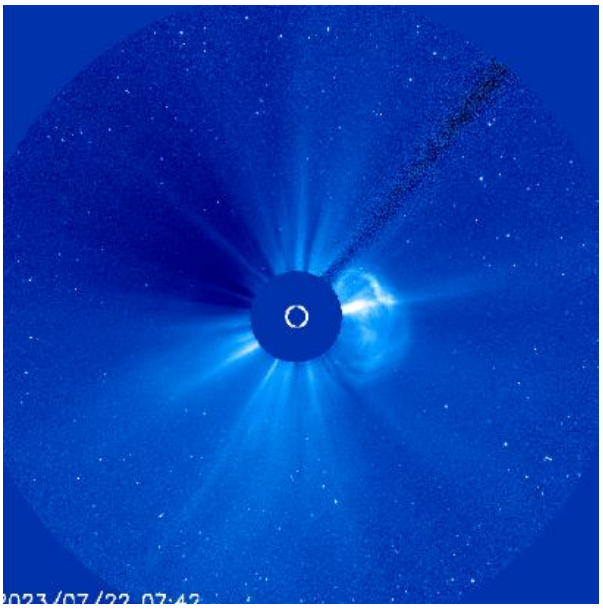
The CME from the M3 flare of AR3372 in the northwest disc, peaking 22/0337 UTC, is still under analysis. Initial suggestions are for this to miss, passing ahead of the Earth, however a glancing impact cannot be ruled out at this stage.

Solar winds are currently slightly elevated with Earth moving into fast wind from CH26. These winds are expected to gradually ease day 2 (23 Jul), before any enhancement from CH27 occurs either late day 2 or through day 3 (23-24 Jul). This enhancement is expected to be relatively weak, with solar winds likely peaking around 450-500km/s and gradually easing later day 4 (25 Jul). This is supported by enlil, although any enhancement is currently arriving earlier within the model than is currently anticipated.

Mainly Quiet to Unsettled geomagnetic activity expected throughout, with a slight chance of Active intervals day 1 (22 Jul) and rising to Active with a slight chance of isolated G1 Minor Storms with any CIR ahead of the CH27/- HSS, most likely on day 3 (24 Jul).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	5	20	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: CME observed from M3 Flare. Analysis ongoing.



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Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate with one M3.1 flare observed from AR3372 in the northwest disc. The disc is currently dominated by a six moderately sized, but relatively simple and stable regions with no recent notable growth observed. There is a chance of further isolated M-flares through the period.

AR3372 is an open structure bipolar region with a simple leader that is now approaching the northwest limb. AR3373, also in the northwest, has a more broken structure to both its leader and trailer, and there are some weak spots that suggest the potential for some subtle complexity, although the overall region structure is broadly bipolar and this spot has remained relatively inactive. AR3376 is the third and most central spot in the northwest, but has seen its trailer region decay, to leave a simple unipolar region. AR3777 in the southeast is another simple bipolar spot dominated by moderately sized and symmetric leader and trailers. AR3778 is currently the smallest of the regions, in the southeast, with a symmetric leader and only a faint trailer region. AR3379 in the northeast is a wide region comprised a moderate sized symmetric leader, along with smaller and simpler following spots.

There are also some suggestions of a further region rotating onto the disc, including visible looping on the east limb, and this has been the source of recent C-flaring. This may currently be the most likely source of any significant flaring.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3a: GOES-16/18 X-ray Flux

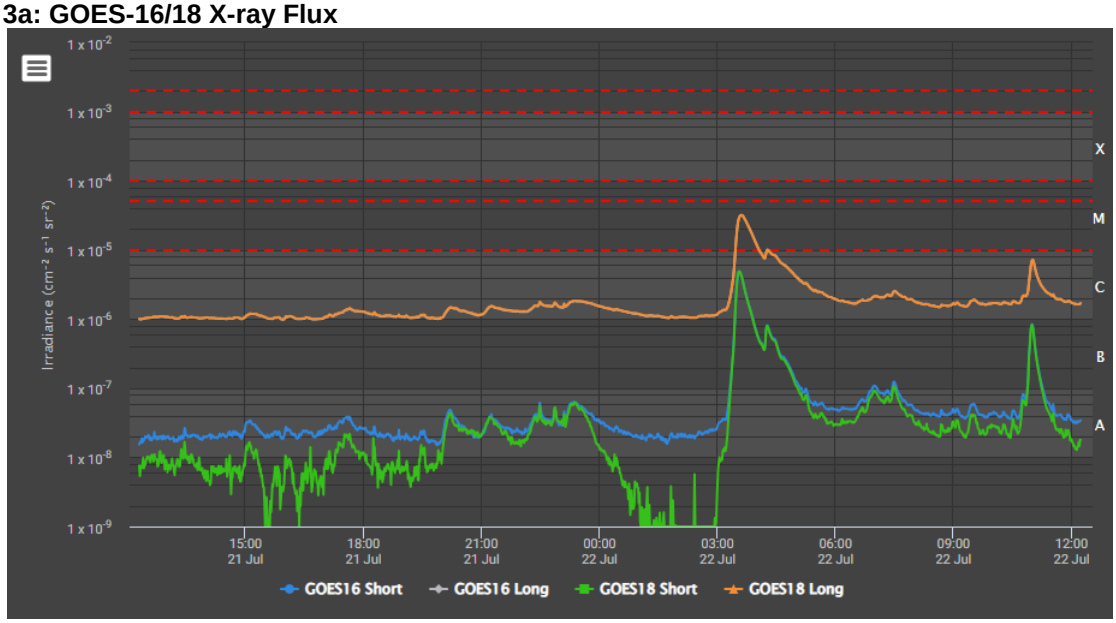

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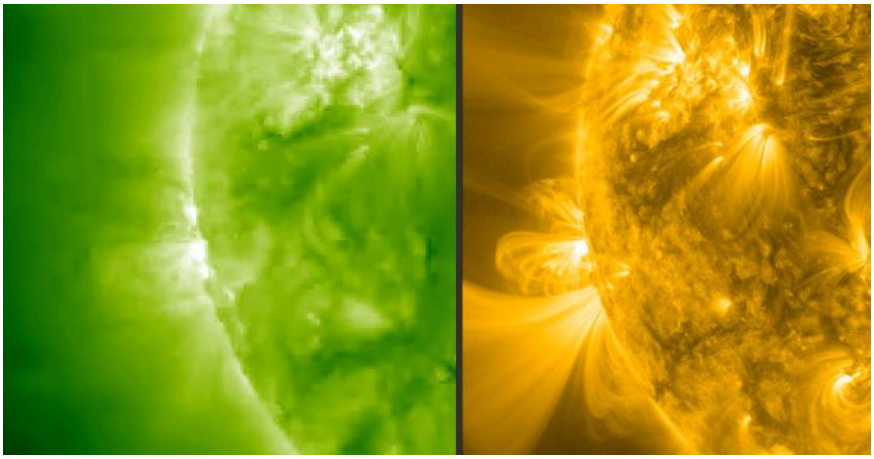
Figure 3b: SDO aia-171 of SE limb and STEREO A euvi of same area, showing potential new region to rotate onto disc.

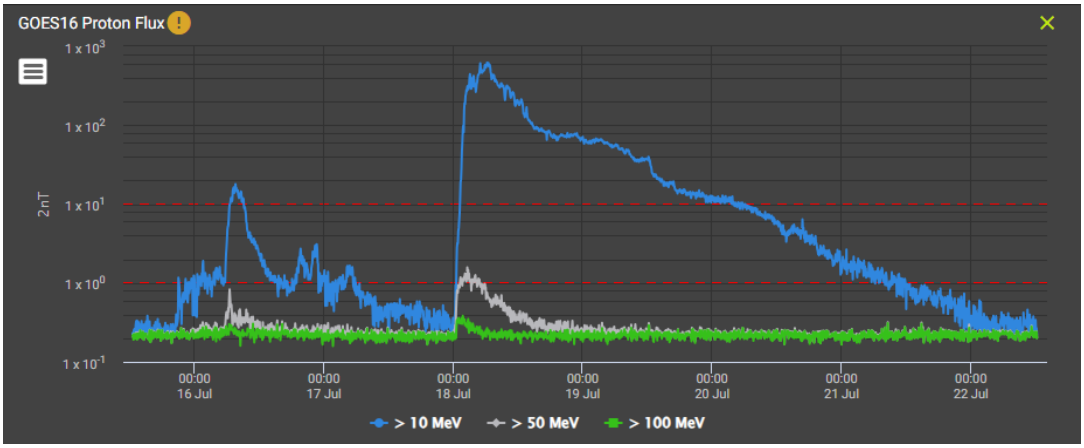


Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES-16, is now at background level after recent enhancements. There remains a chance of further increases in flux, primarily due to regions on the western hemisphere and any associated flare that these may produce, with an ongoing very slight chance of reaching the S1/Minor Radiation Storm threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 >10MeV, >50MeV and >100MeV Proton flux for the last week



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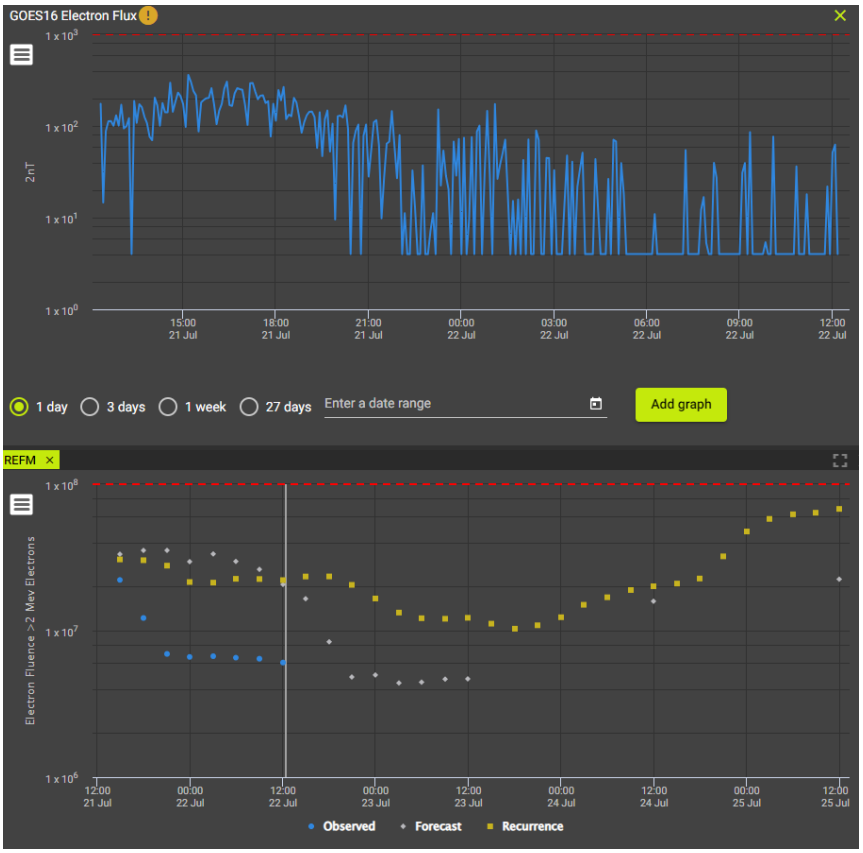
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) is currently varying between background and diurnal peaks of moderate. With recent coronal hole HSS and CME enhancements, flux is likely to rise further, and there is a chance of approaching peak high levels (above 1000 pfu), at times through the period. However this most likely by day 4 (25 Jul) depending upon the strength of any further enhancement from CH27/- located in the northern hemisphere. This is currently expected to occur either late day 2 (23 Jul) or during day 3 (24 Jul).

The associated 24 hour fluence is expected remain below the Active threshold (1e8 total pfu) through the period, albeit with a gradual rising trend, There is a slight chance of rising above this level, most likely by the end of day 4 (25 Jul). This is supported by REFM which is currently proving reasonable guidance with expected trends, although is currently overestimating the observed level.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 >2MeV Electron flux (top) and associated fluence with REFM and Recurrence (bottom)



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